MINT: <u>M</u>id-continent <u>INT</u>ensive airborne trace gas measurements
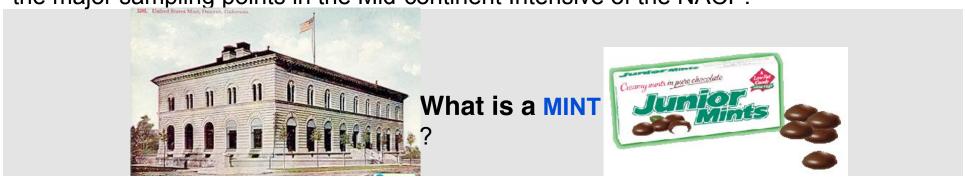
Steven Wofsy, Daniel M. Matross, and J. William Munger

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Division of Engineering and Applied Sciences
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MINT: Mid-continent Intensive *in situ* aircraft sampling program

The North American Carbon Program envisions combining a network of multiple types of observations including eddy covariance fluxes, process studies, concentration observations from tall and short towers, routine vertical profiles and the global flask network to derive regional and continental scale fluxes, seasonally resolved, for major carbon gases (CO_2, CO, CH_4). Data assimilation models will link fluxes at the local (eddy covariance) with concentrations responding to large regional and continental scales (tall towers).

Intensive *in situ* airborne budget experiments play a critical role for testing "scaling-up" techniques and for evaluating models at multiple scales. MINT is the first of these. It will provide direct estimates of fluxes at scales large enough to relate directly to tall tower observations, but small enough that they contain a manageable diversity of ecosystem types and focus on the area of study in the Mid-continent Intensive. The measurements will comprehensively sample the atmosphere upwind of the major sampling points in the Mid-continent Intensive of the NACP.

What is a MINT ?

MINT: What it will measure, how the measurements will be used

What measured: MINT will measure the major carbon cycle gases, CO_2, CH_4, **and CO,** plus major indicator species for urban/industrial pollution (**CO, SF_6**), intensive agriculture (**N_2O**), and net oxidative processes (**O_2/N_2**). In addition indicators of atmospheric structure and boundary layer development (**O_3, H_2O**) will be measured.

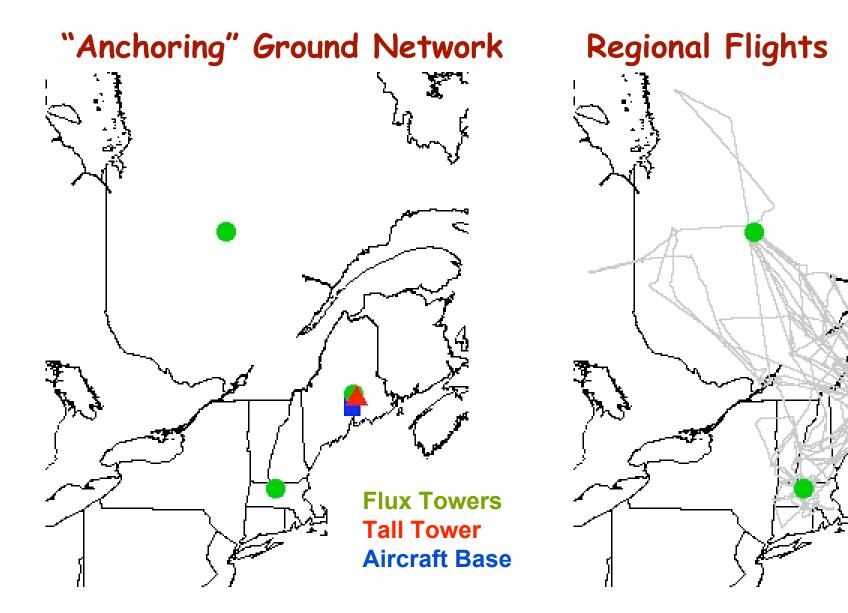The **U. Wyoming King Air** is the platform of choice.

How used: MINT data will be analyzed to provide ***direct estimates of fluxes*** for comparison with bottom-up budgets from field experiments and top down estimates from the tall tower network, focusing on 20 1-2 day periods between April, 2007 and November, 2007.

MINT data will assess and check the inputs and outputs of the principal models used for data assimilation and upscaling. All models used for analyzing tall tower data produce or use information on atmospheric concentrations distant from the receptor, including concentrations in air advected into the region, changes in concentrations during transit of the region, height of the Planetary Boundary Layer, wind speeds and direction, etc.

MINT data will establish the errors inherent in all of these quantities.

A Scientific Program Overview (SPO) and Experiment Design Overview (EDO) have been submitted for MINT *to NSF, and a full proposal will be submitted by 01 March, or as soon as the configuration of Mid-continent Intensive in 2007 is sufficiently defined.*
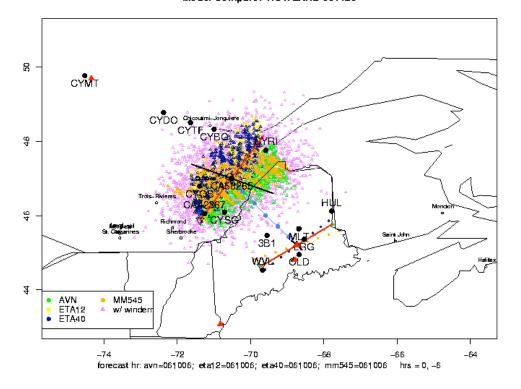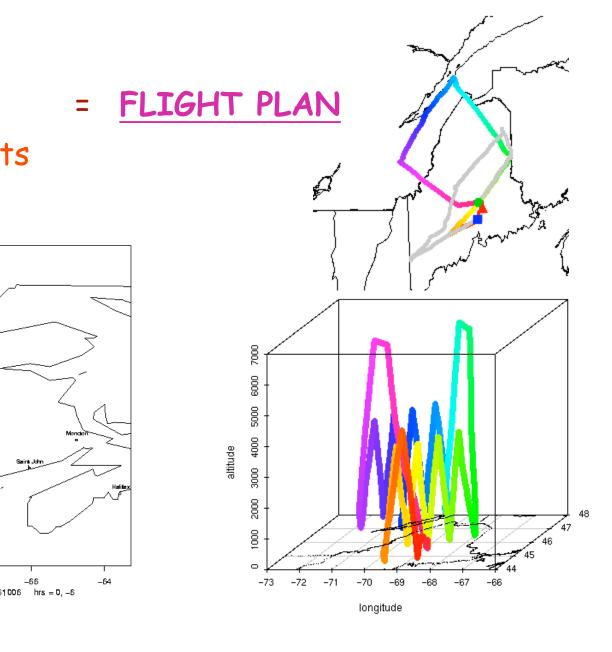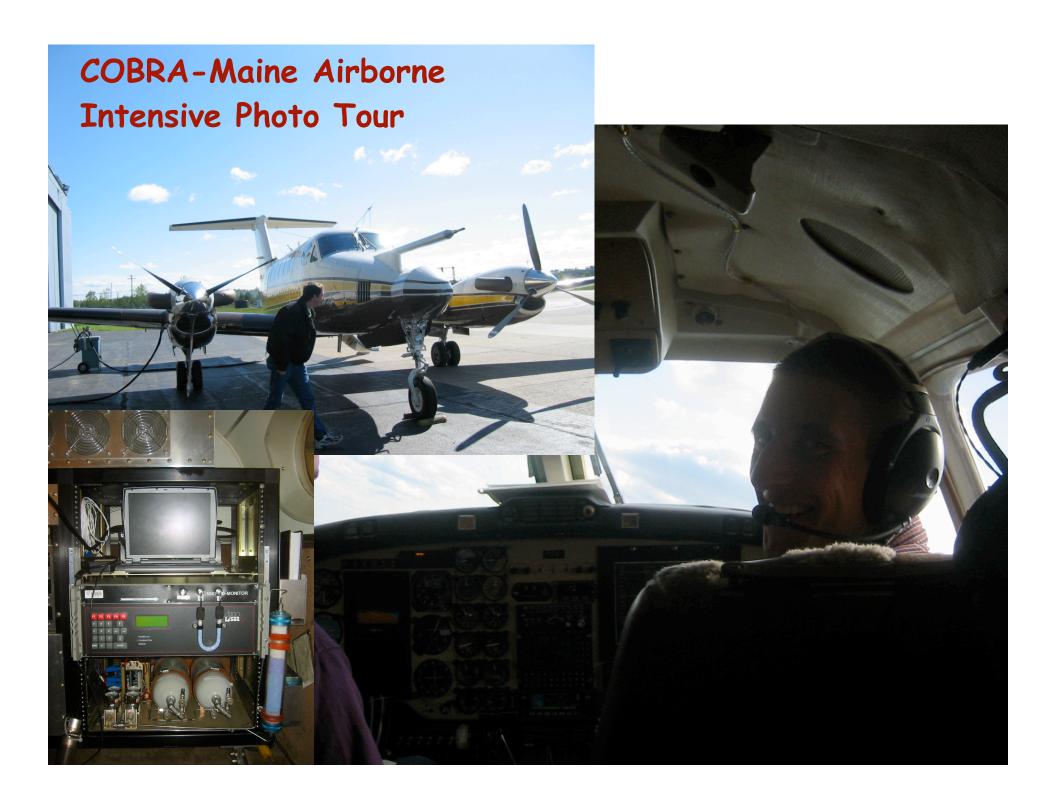
COBRA-Maine Mission Design:
A template for MINT

"Anchoring" Ground Network

Regional Flights

Flux Towers
Tall Tower
Aircraft Base

COBRA-Maine Flight Planning

Forecast +

Science Objectives +

Operational Constraints

= FLIGHT PLAN

Model Compare: HOWLAND 061120

forecast hr: avn=061006; eta12=061006; eta40=061006; mm545=061006   hrs = 0, -6

Legend:
AVN
ETA12
ETA40
MM545
w/ winderr

COBRA-Maine Airborne
Intensive Photo Tour

Time [GMT on 11-June-2004]

COBRA-Maine CO2 Profiles near Argyle 11-June-2004

COBRA 11-June-2004 Flights
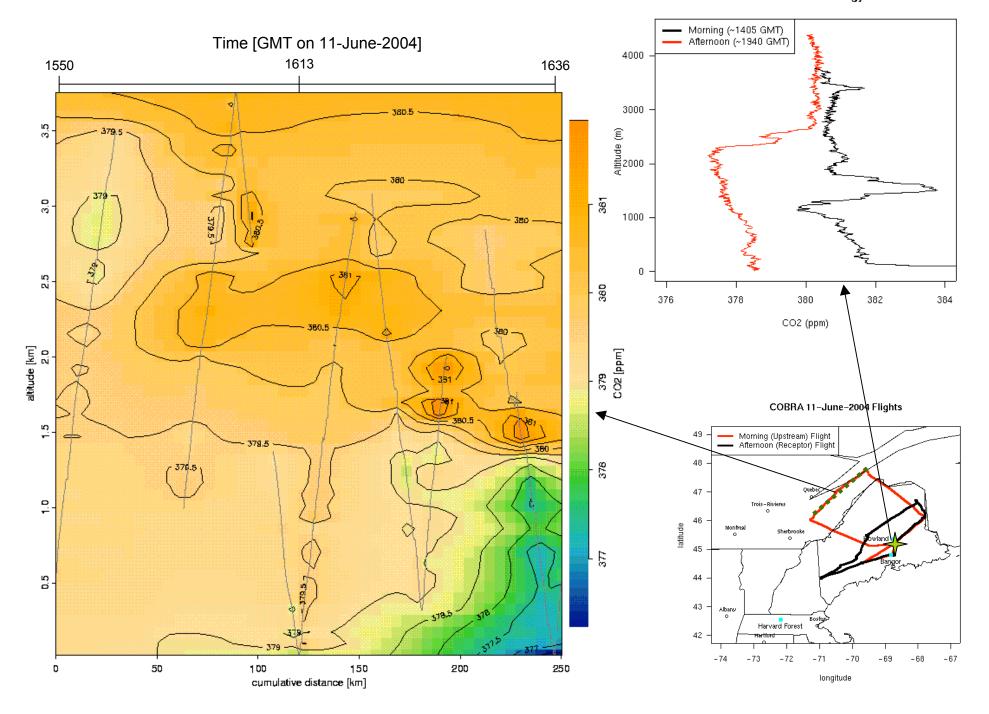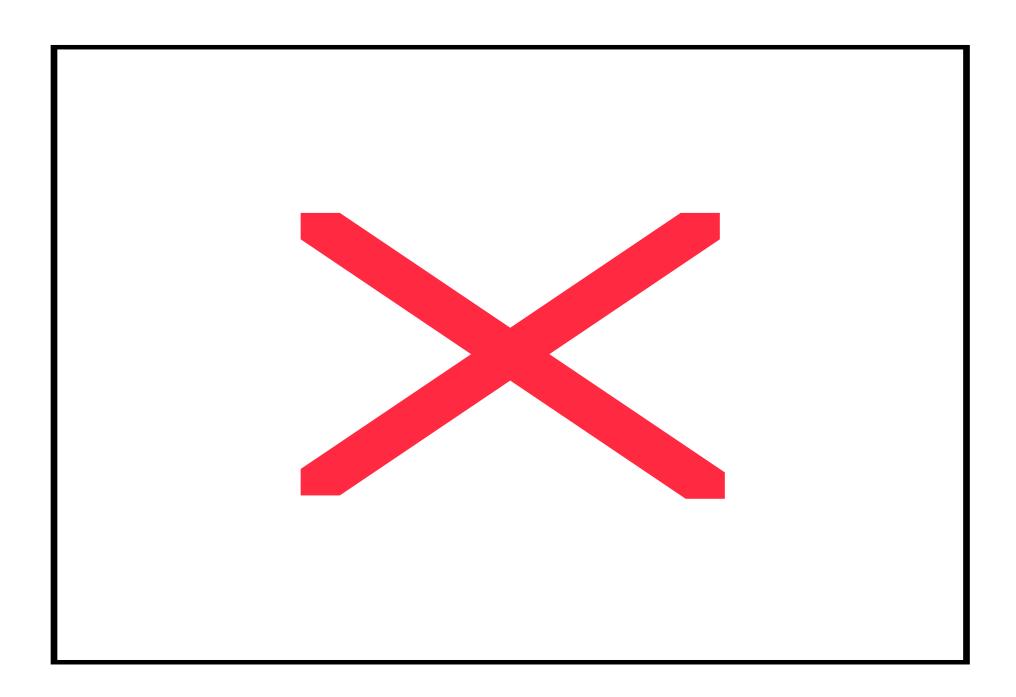
MINT Payload & Flight Summary

• Flights will be coordinated with ACME observations over the Rockies

•There will be two Intensive Operating Periods (IOPs) , dates under discussion.

      1. May-June 2006 (ending 01 or 04 July 2006)

      2. September-October 2006

•Payload given on the next slide.

• Sample flight profiles are given in the following slides.

•**MINT** may also include limited funds to facilitate installation of GMD tall tower measurement systems in a timely manner, and for extending the observations to include ozone profiles on the towers.

ACME/MINT SCIENTIFIC PAYLOAD

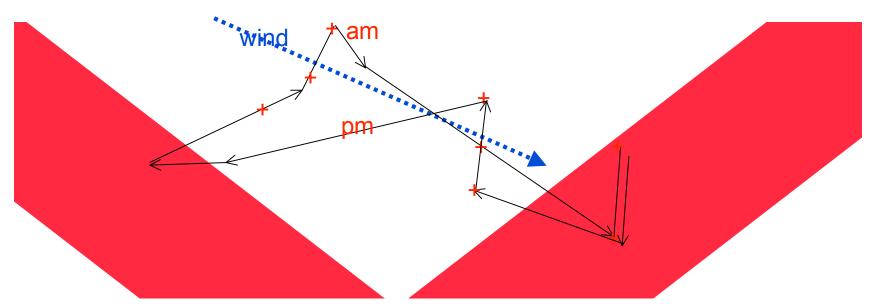| Instrument	Wt (lbs)	Size	Power: watts, amps	Power Type: AC, DC, Hz
a. Harvard Quantum Cascade Laser Spectometer (CO_2 CO, N_2O and CH_4)	150	50 vertical inches, 19 inch rack, 25 deep	300 cont., 1200 max	28 vDC
b. Airborne Oxygen Instrument (O_2/N_2 ppm): B. Stephens, NCAR	100	40 vertical, 19" rack, 25 deep	1000 watts continuous	28 VDC
c. Compact gas chromatograph (CFCs, SF_6); UV absorption, O_3; tunable diode laser, H_2O): J Elkins, GMD-NOAA	70	25 vertical inches, 19 inch rack, 25 deep	200 watts, max 400	28 VDC
d. Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA): Airborne flask collection system for carbon isotopes (^{13}C, ^{18}O)	85	40 vertical inches, 19 inch rack, 25 inches deep	4 A @ 28 VDC, 150 watts	28 VDC

MINT operational area focuses on Iowa, Nebraska, N. and S. Dakota, Northern Kansas, Minnesota, and Wisconsin. The map shows this area, plus airports to be used for landing and refueling.

MINT will sound to ground level using "missed approaches" at rural airports throughout the operational area.
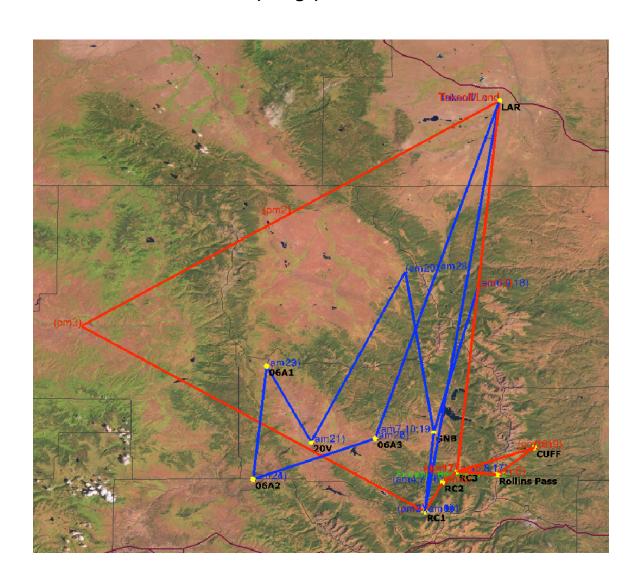
The basic pattern samples upwind/within the main focus areas with variants depending on air flow and on which tall tower is the anchor. We can reach Park Falls (WLEF) and any towers from Southern Minnesota, through Iowa, to Northern Missouri.

Example mission: Depart Laramie, transit to an area upwind of the anchor, undertake missed approaches (+) at 2-5 rural airports en route, plus numerous descents in between, pass at inlet level by the tall tower, land in Des Moines. After 2-4 hours, take off, repeat downwind of the first area, and return to Laramie. The pattern can go farther north, e.g. to Grand Forks, or south (Nebraska) as needed, and a short midday flight is possible if desired. We may overnight in Des Moines to start an early flight the next day.

Distances: 1150 km (623 nm) Laramie - Cedar Rapids, 1300 km (715 nm) to Park Falls.

ACME sampling plan from Laramie

MINT Summary

MINT is a component of the *Mid-Continent Intensive of the NACP*. It is an intensive *in situ* aircraft sampling program using the Wyoming King Air, with a compact payload able to measure a comprehensive suite of carbon cycle gases, tracers of agricultural systems, indicators of urban/industrial pollution, and parameters defining atmospheric circulation and structure.

MINT is proposed for the time period April-November 2007.

The purpose of **MINT** is to rigorously check the top-down and bottom-up budgets being developed in the Mid-continent Intensive. **MINT** will provide:

(1) Direct independent determination of surface fluxes and regional budgets for **CO_2, CH_4, CO, N_2O, and O_2** (via O_2:N_2 ratio).
(2) Direct measurements of the critical inputs, drivers, and outputs of the data assimilation models used to determine regional fluxes from tall tower data.

A funding decision on **MINT** is expect in July, 2006.